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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EMF3056 – MICROWAVE MEASUREMENT TECHNIQUES (MCE)

4 MARCH 2016
9.00 A.M- 11.00 A.M.
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 5 pages with 4 Questions only.
2. Answer all **FOUR (4)** questions. Question 1 and 3 carry 17 and 33 marks respectively while Question 2 and 4 carry equal marks of 25. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

- a) Explain briefly THREE (3) types of RF/Microwave power measurements. [6 Marks]
- b) The procedures of measuring gain for a power amplifier with filter and radio frequency (RF) cables are illustrated below (Figure Q1) :

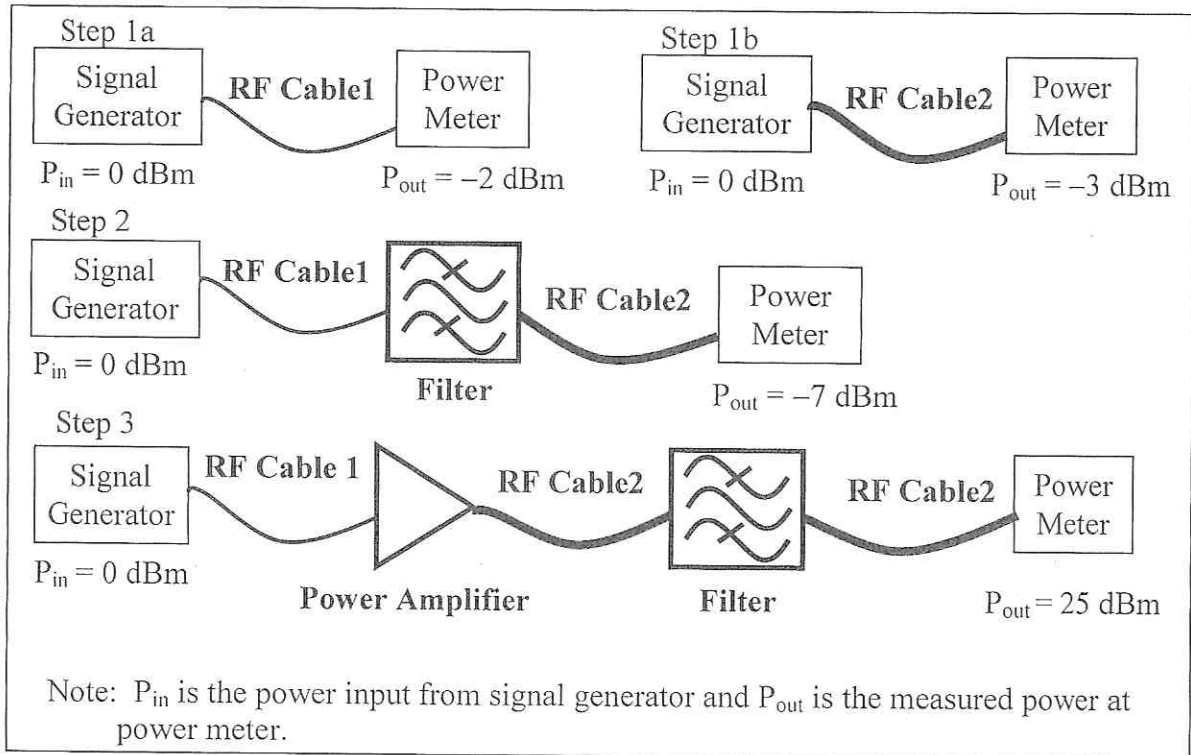


Figure Q1

- (i) State a reason of using a filter in the above measurement. [1 Mark]
- (ii) What are the power losses contributed by the RF Cable1 and RF Cable2? [2 Marks]
- (iii) Determine the insertion loss of the filter. [2 Marks]
- (iv) Determine the gain of the power amplifier. [2 Marks]
- (Hints : Ignore the loss of connectors and assume all connectors and RF cables are the same)
- c) List TWO (2) advantages and TWO (2) disadvantages of network analysis method for impedance measurement. [4 Marks]

Continued...

Question 2

- a) Explain the principle of operation for a swept-tuned spectrum analyzer using a block diagram. [9 Marks]
- b) List FOUR (4) advantages of vector network analyzer (VNA) over scalar network analyzer (SNA). [4 Marks]
- c) A coaxial filter is connected in between the multi-tone signal generator and spectrum analyzer as shown in Figure Q2.
(Assume that the connecting cables and connectors have no loss)

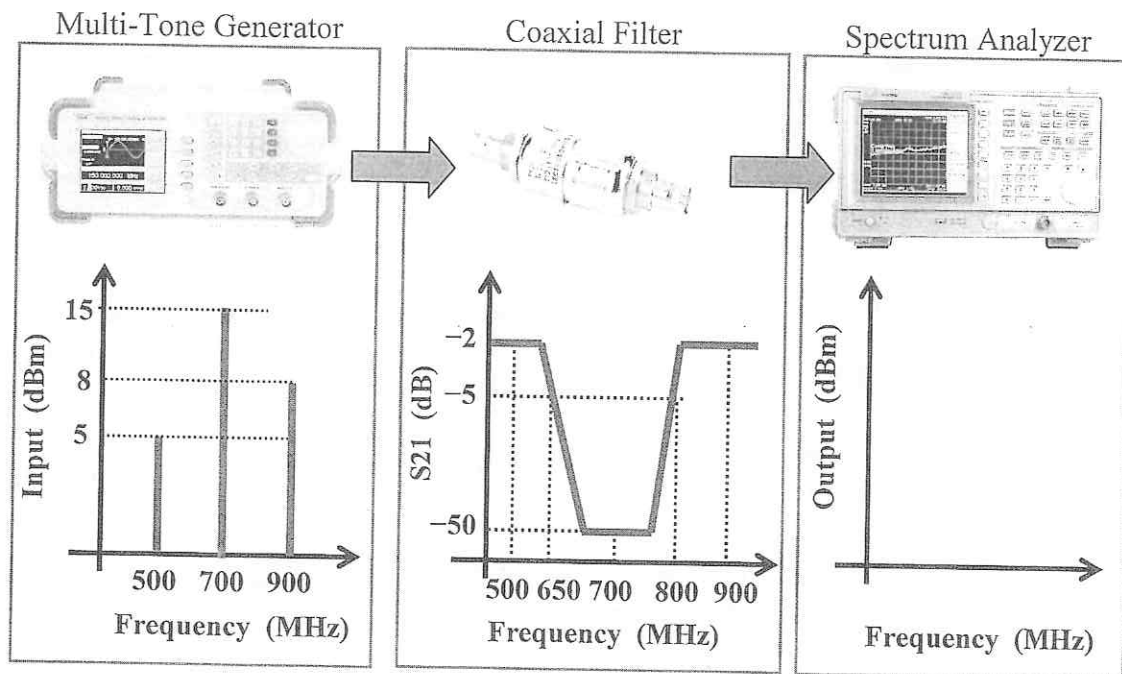


Figure Q2

- (i) What type of filter is shown in the above measurement? [1 Mark]
- (ii) Determine the insertion loss, pass-band frequencies, cut-off frequencies and 3 dB bandwidth of the filter. [6 Marks]
- (iii) What are the stop-band frequency and rejection of the filter? [2 Marks]
- (iv) Sketch the output of the spectrum analyzer in the graph above and indicate the frequency points and power level. [3 Marks]

Continued...

Question 3

- a) Explain briefly THREE (3) errors occurred in a typical vector network analyzer measurement. [6 Marks]
- b) A device under test (DUT) has the following S -parameters (in touchstone or S2P file format) before and after the 2-port Short-Open-Load-Thru (SOLT) calibration, as shown in Figure Q3.

! Un-calibrated										
! S11 S21 S12 S22										
# GHz S MA R 50										
.100	1.000	-10.5	9.271	172.8	.014	83.1	.830	-6.9		
.200	.983	-20.2	9.176	165.5	.027	76.6	.825	-13.8		
.300	.977	-31.4	8.885	158.5	.040	70.7	.803	-20.1		
.400	.964	-41.1	8.652	151.9	.051	65.1	.784	-26.3		
.500	.928	-50.4	8.301	144.4	.061	58.6	.745	-32.7		
.600	.907	-59.3	7.956	138.5	.071	53.8	.722	-37.9		
.700	.885	-67.6	7.607	132.8	.078	49.2	.691	-43.2		
.800	.864	-75.3	7.262	127.6	.085	44.9	.665	-47.9		
.900	.847	-82.6	6.904	122.6	.091	41.0	.641	-51.8		
1.000	.828	-89.2	6.591	117.9	.096	37.5	.614	-55.8		

! SOLT calibrated										
! S11 S21 S12 S22										
# GHz S MA R 50										
.100	.100	-80.5	12.27	122.8	.004	83.1	.130	-6.9		
.200	.183	-90.2	12.17	125.5	.017	76.6	.125	-3.8		
.300	.177	-91.4	11.85	138.5	.020	70.7	.103	-5.1		
.400	.164	-91.1	11.62	161.9	.011	65.1	.084	6.3		
.500	.128	-90.4	11.30	184.4	.031	58.6	.045	2.7		
.600	.090	-99.3	10.56	118.5	.011	53.8	.022	3.9		
.700	.085	67.6	10.67	152.8	.018	49.2	.091	4.2		
.800	.064	25.3	10.62	117.6	.025	44.9	.065	4.9		
.900	.047	2.6	10.04	112.6	.011	41.0	.041	5.8		
1.000	.028	0.0	10.91	107.9	.016	37.5	.014	0.0		

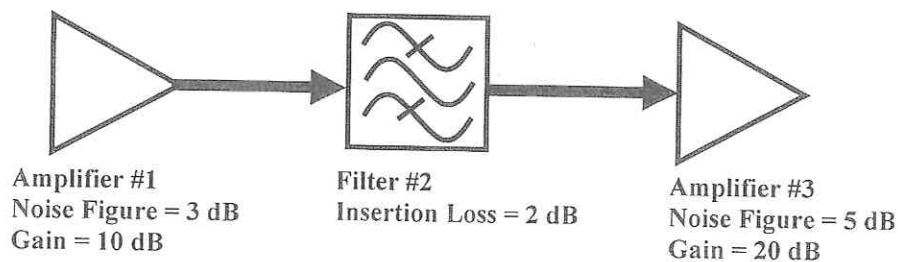
Figure Q3

- (i) Explain briefly THREE (3) advantages of 2-port SOLT calibration. [6 Marks]
- (ii) List THREE (3) errors removed by 2-port SOLT calibration. [3 Marks]
- (iii) Determine the frequency range and reference impedance used in the above measurements. [2 Marks]
- (iv) Determine the input impedance (Z_{in}) and output impedance (Z_{out}) of the DUT before and after performing the calibration at 1 GHz. [4 Marks]
- (v) Are the input and output of the DUT matched to reference impedance, after performing the 2-port SOLT calibration at 1 GHz? Justify your answer. [2 Marks]
- (vi) Determine the input and output return losses of the DUT before and after performing the calibrations at 1 GHz. [4 Marks]
- (vii) Is the above DUT has power gain or power loss at 1 GHz? Justify your answer. [2 Marks]
- (viii) What is the power gain or power loss of the above DUT in dB at 1 GHz? [2 Marks]
- (ix) What is the isolation the above DUT in dB at 1 GHz? [2 Marks]

Continued...

Question 4

- a) An RF signal with a power of 1 mW and noise level of 0.01 mW is connected to an amplifier with power gain of 10 dB. The noise level measured at the amplifier output is approximately 0.15 mW. Determine the input signal-to-noise ratio, output signal-to-noise ratio and noise figure contributed by this amplifier. [6 Marks]
- b) An amplifier with noise figure of 3 dB and power gain of 10 dB is connected to the input of a filter with insertion loss of 2 dB and then followed by an amplifier with noise figure of 5 dB and power gain of 20 dB (as shown in Figure Q4). Determine the total power gain (in absolute unit and decibel, dB), noise factor and noise figure contributed by this system. [9 Marks]

Figure Q4

- c) Derive the relationship between Noise Figure and Effective Input Noise Temperature of an amplifier. [4 Marks]
- d) A noise source is connected to a preamplifier and the noise power is measured using a spectrum analyzer. The measured hot and cold noise power is -90 dBm and -96 dBm, respectively. Given that the Excess Noise Ratio (ENR) of a noise source is 15 dB. Calculate the noise figure of the system (in dB). [6 Marks]

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